New preliminary measurement of the mass of the top quark at DØ using Run I data

F. Canelli, T. Ferbel
University of Rochester

J. Estrada, G. Gutierrez
Fermilab

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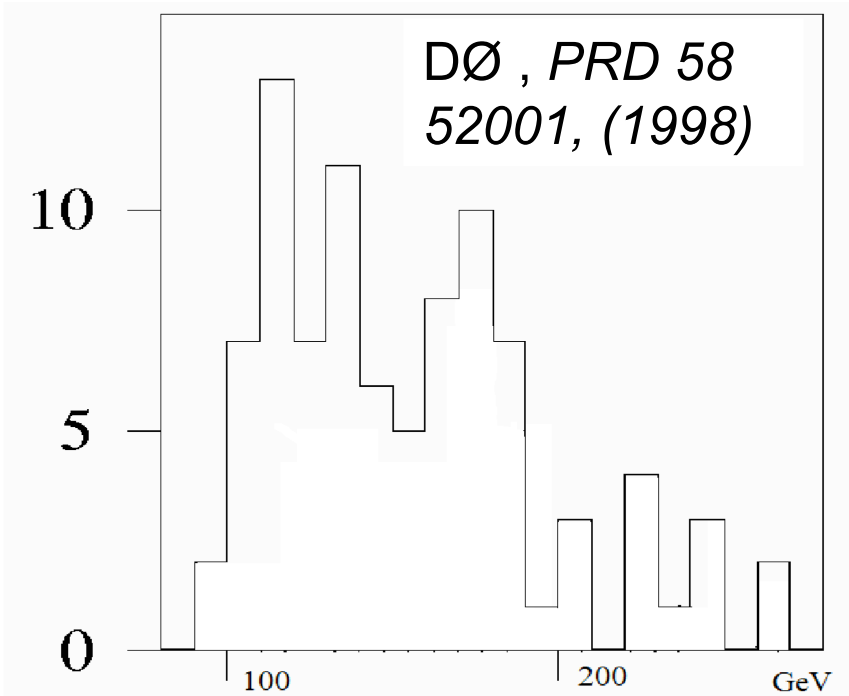
Overview

- **The lepton+jets decays of the top quark**
- **Method used for this analysis compared to our previous measurement.**
- **New preliminary Run I M_t measurement**
- **Conclusion**

..it is a challenging problem and that is why we have been applying **sophisticated methods** making good use all the information that we have.



fitted mass

Event topology and selections

DØ Statistics RunI (125 pb^{-1})

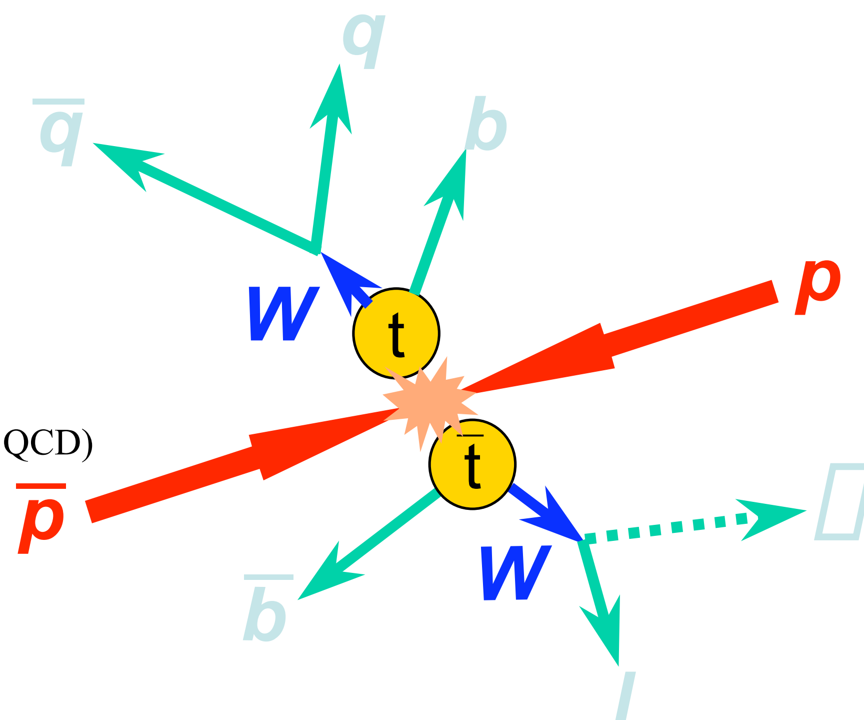
Standard Selection :

- Lepton: $E_t>20$ GeV, $|\eta^e|<2$, $|\eta^\mu|<1.7$
- Jets: ≥ 4, $E_T>15$ GeV, $|\eta|<2$
- Missing $E_T > 20$ GeV
- "E_T^W" > 60 GeV ; $|\eta_W|<2$

•gives 91 events

Ref. PRD 58 (1998), 052001:

After χ^2: 29 signal + 48 backg. (0.8 *W+jets* and 0.2 QCD) (77 events)



12 jet permutations/event

Additional cuts for this analysis:

4 Jets only : 71 events

Background Prob. : 22 events

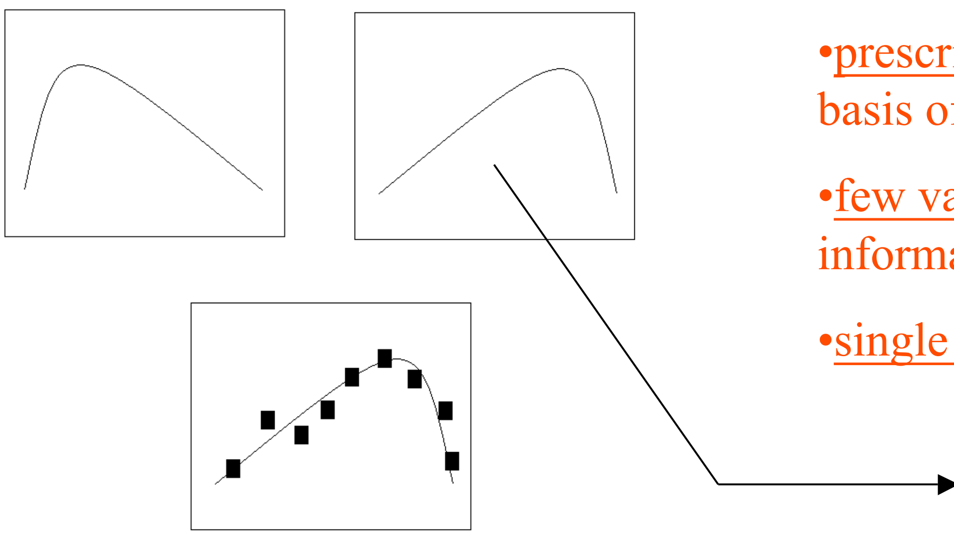
Template method

Previous DØ and CDF publications

Reducing the dimensionality of the problem

A multidimensional (x_i) template is obtained for each value of the input mass, and the data sample is then compared with those MC templates to find the most likely value for $\boldsymbol{M_t}$:

Template(x_i;$\boldsymbol{M_t}$=A)   Template(x_i;$\boldsymbol{M_t}$=B)



Sample probabilities

Data => $\boldsymbol{M_t}$~B

Some limitations:

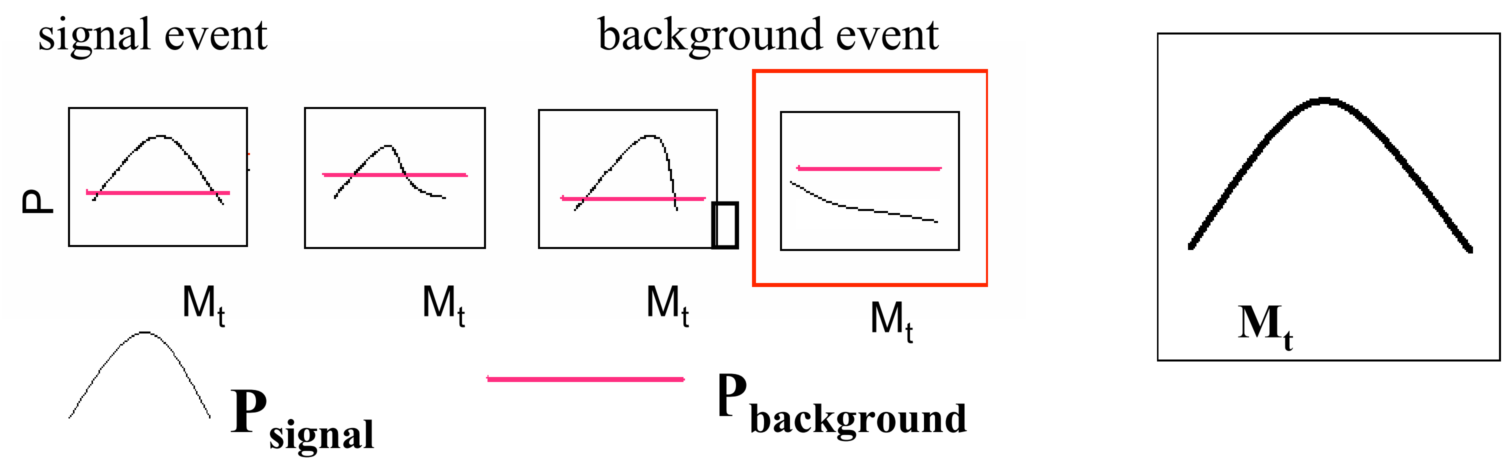
•prescribed permutation is selected on basis of a kinematic fit.

•few variables, containing most of the information, are selected for the templates.

•single template fits the whole sample.

Measurement of M_t using event probability
(before we get into de details)

The probability for each event being signal is calculated as a function of the top mass. The probability for each event being background is also calculated. The results are combined in one likelihood for the sample. (Similar to the methods of Dalitz, Goldstein and Kondo, M_t measurement in the dilepton channel by DØ - PRD **60** 52001 (1999) and idea by Berends et al for W^+W^- production.)



Three differences between the two approaches

Template Method

1. All the events are presented to the **same template**. Average probability distribution.
2. The template corresponds to a probability distribution for the entire sample, using **selected variables** calculated from MC simulations.
3. The **features of individual events are averaged** over the variables not considered in the template.

This analysis

1. Each event has its **own probability distribution.**
2. The probability depends on **all measured quantities** (except for unclustered energy).
3. Each event contributes with its own specific features to the probability, which **depends how well is measured**.

Calculation of signal probability

If we could **access all parton level quantities** in the events (the four momentum for all final and initial state particles), then we would simply **evaluate the differential cross section as a function of the mass of the top quark for these partons**. This way we would be using our best knowledge of the physics involved.

Since we do not have the parton level information for data, we use the differential cross section and **integrate over everything we do not know**.

$$P_{t\bar{t}}(x) = \frac{1}{\sigma_{tot}} \int d\sigma(y)\, dq_1 dq_2 f(q_1) f(q_2) W(x,y)$$

Transfer function W(x,y)

W(x,y) probability of measuring **x** when **y** was produced (***x*** jet variables, ***y*** parton variables):

$$W(x,y) = \delta^3(p_e^y - p_e^x)\prod_{j=1}^{4} W_{jet}(E_j^y, E_j^x)\prod_{i=1}^{4}\delta^2(\Omega_i^y - \Omega_i^x)$$

where

E^y	energy of the produced quarks
E^x	measured and corrected jet energy
p^y_e	produced electron momenta
p^x_e	measured electron momenta
Ω^y_j Ω^x_j	produced and measured jet angles

Energy of electrons is considered well measured, an extra integral is done for events with muons. Due to the excellent granularity of the D∅ calorimeter, angles are also considered as well measured. A sum of two Gaussians is used for the jet transfer function (W_{jet}), parameters extracted from MC simulation.

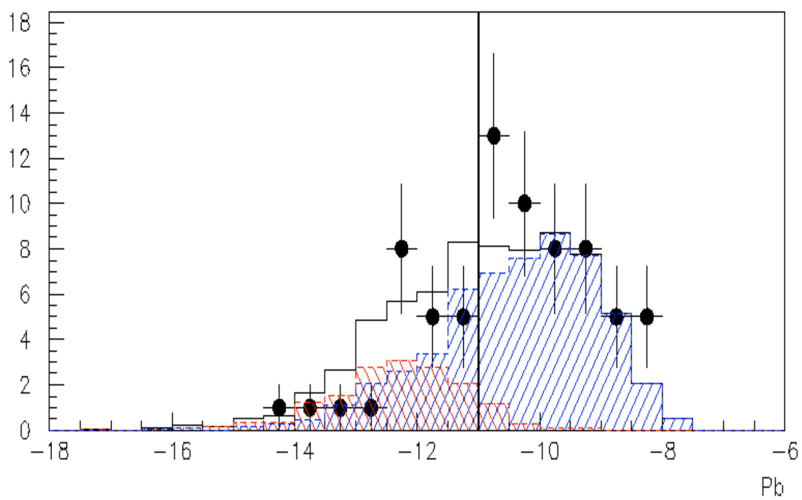
Signal and Background

$$-\ln L(\alpha) = N \int \overbrace{A(x)\left[c_1 P_{tt}(x;\alpha) + c_2 P_{bkg}(x)\right]}^{\text{Detector acceptance corrections (from MC)}} dx$$

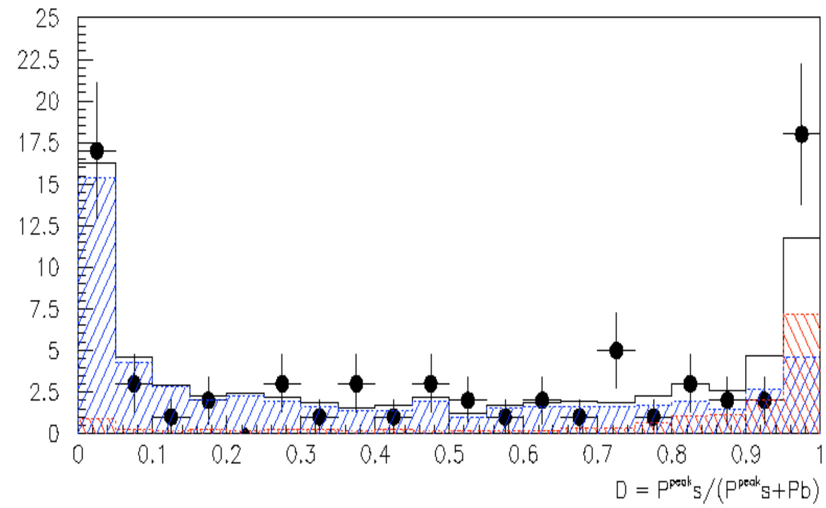
$$- \sum_{i=1}^{N} \left\{ \ln\left[c_1 P_{tt}(x_i;\alpha) + c_2 P_{bkg}(x_i)\right] \right\}$$

- **The background probability is defined only in terms of the main backgound** (W+jets, 80%) which proves to be also adequate for multijet background treatment in this analysis.
- The background probability for each event is calculated using **VECBOS subroutines for W+jets**.
- The values of **c_1 and c_2 are optimized**, and the likelihood is normalized automatically at each value of α.

Probabilities in Data



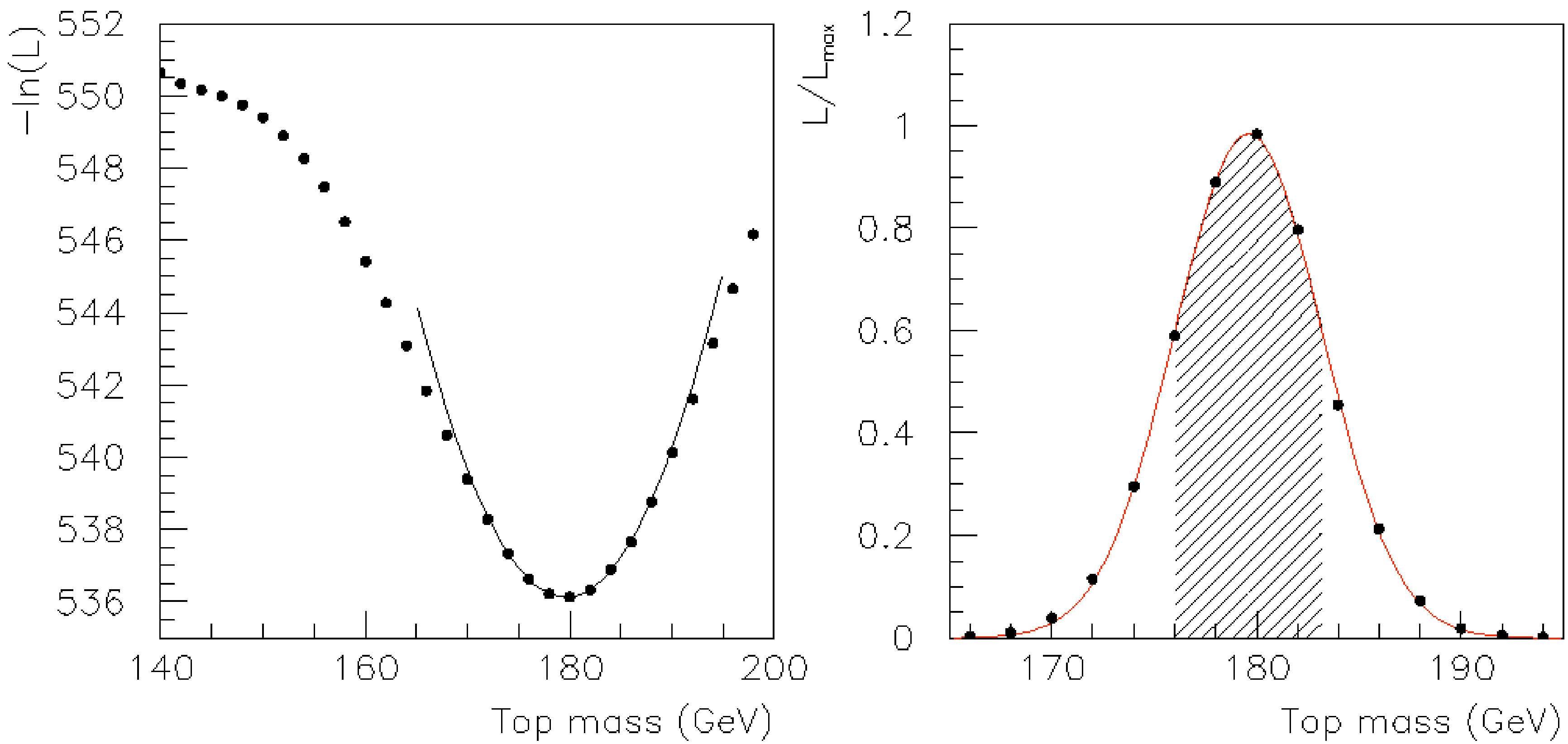
Background probability



Discriminator

Comparison of (16 signal + 55 background) MC and data sample before the background probability selection. An extra cut is applied in the background probability (vertical line) to purify the sample, this reduces the final sample to 22 events.

New Preliminary Result

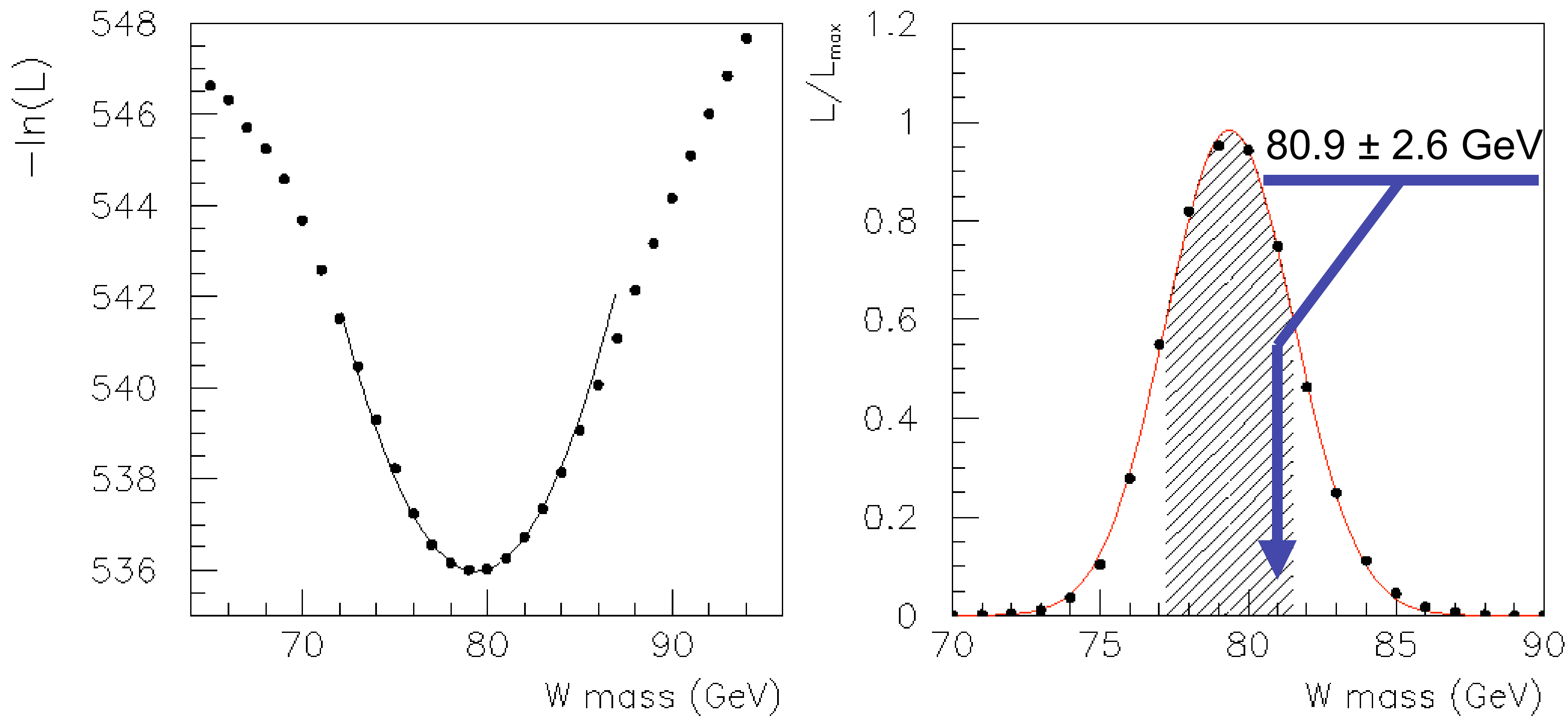


M_t= 180.1 ± 3.6 GeV ± SYST - preliminary

This new technique improves the statistical error on M_t from 5.6 GeV [PRD 58 52001, (1998)] to 3.6 GeV. This is equivalent to a factor of 2.4 in the number of events. 22 events pass our cuts, from fit: (12 s + 10 b)

(0.5 GeV shift has been applied, from MC studies)

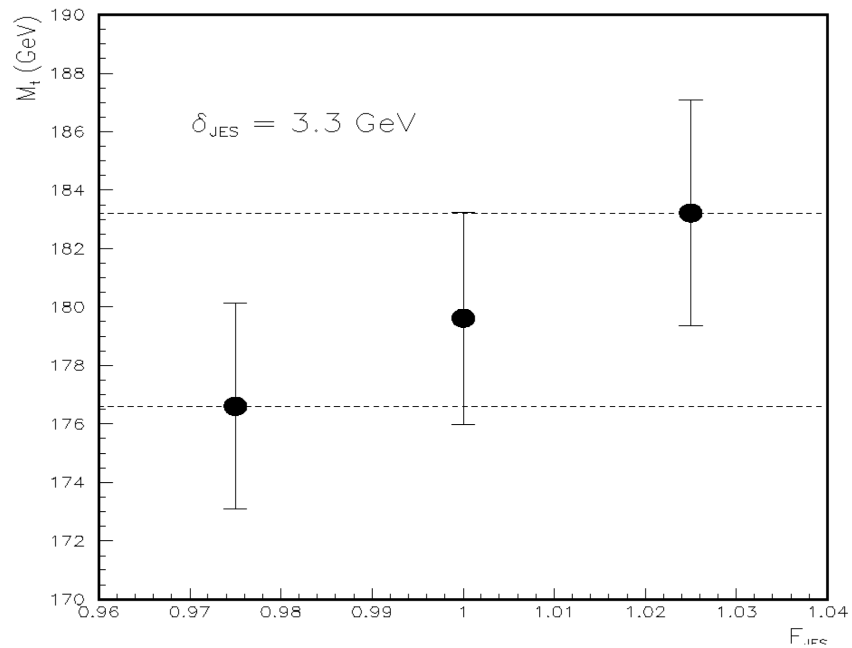
Check of M_W with DØ Run I Data



Can help reduce the uncertainty in the jet energy scale (JES)
see:http://dpf2002.velopers.net/talks_pdf/120talk.pdf (DPF2002 proceedings)
1.5 GeV shift is applied and 20% increase in the error, from MC studies. We associate this shift to effects from our L.O. approximation.

Jet Energy Scale (main systematic effect)

- We use a **Monte Carlo simulation of the detector to build the transfer function** (or the templates in our previous analysis).
- It is essential to **check that the jet energy scale in the MC simulation is representative of that in the detector**. Our **γ+jet sample gives 2.5% uncertainty in JES.**



The analysis is repeated after scaling the jet energies by the uncertainty for each jet: ±(2.5%+0.5 GeV).

δ_{JES}=3.3 GeV

Total Uncertainty

I. Determined from MC studies with large event samples:

Signal model	1.5 GeV
Background model	1.0 GeV
Noise and multiple interactions **PRD 58 52001, (1998)**	1.3 GeV

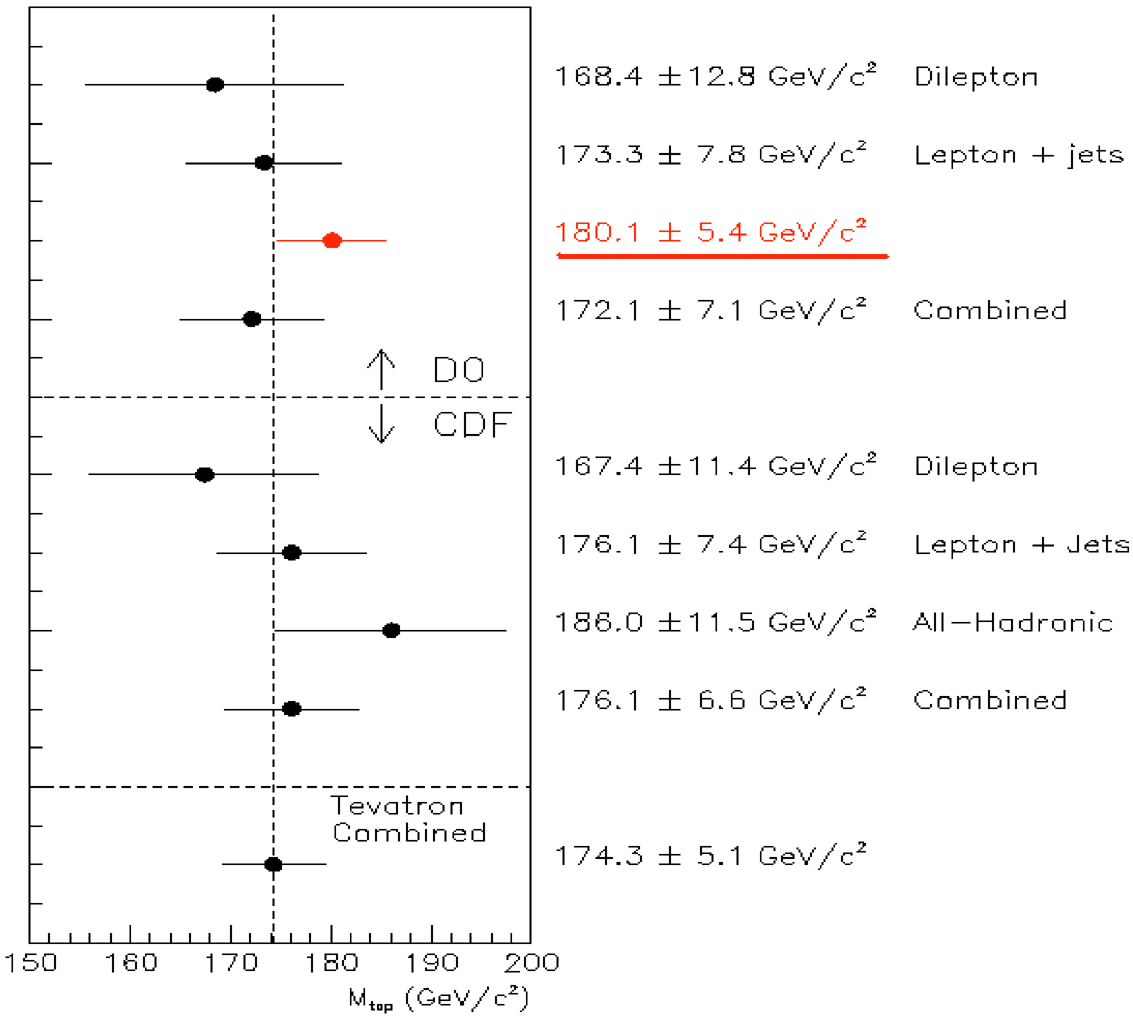
II. Determined from data:

Jet Energy Scale	3.3 GeV
Parton Distribution Function	0.2 GeV
Acceptance Correction	0.5 GeV

Total systematic: 4.0 GeV

$$\mathbf{M_t = 180.1 \pm 5.4\ GeV\ \ (preliminary)}$$

New [preliminary] Result



The relative error in this result is 3%, compare to 2.9% from the previous CDF and DØ combined average for all channels.

Conclusions

Using LO approximation (and parameterized showering) we calculated the event probabilities, and measured:

$$M_t = 180.1 \pm 3.6\ (\mathrm{stat}) \pm 4.0\ (\mathrm{syst})\ \mathrm{GeV} \quad \textbf{preliminary}$$

Significant improvement to our previous analysis, is equivalent to 2.4 times more data:

1. Correct permutation is always considered (along with the other eleven)
2. All features of individual events are included, thereby well measured events contribute more information than poorly measured events.

To consider for the future:

- The possibility of checking the value of the *W* mass in the hadronic branch on the same events provides a **new handle on controlling the largest systematic error**, namely, the jet energy scale.
- A very general method (application to W boson helicity, Higgs searches, ….)